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Sixteen Years of Selection for Weaning Weight, Final Weight, and Muscling Score in Hereford Cattle

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Introduction

Selection is the primary force for changing average genetic composition of herds, breeds, or species. Individual changes from one generation to the next associated with selection are usually small. In time, however, the change can be dramatic.

Selection is deciding which bulls and cows get to become parents and how many offspring we allow them to have. Both the will of man and the will of nature are directive forces in selection. Rate of progress from selection is determined by (1) average selection differential of parents for all traits under selection, (2) heritability of traits, (3) genetic correlations between traits, and (4) interval between generations of parents.

Selection differential is the difference in performance of selected sires and dams compared with the average of the unselected group from which they came.

Heritability is the fraction of the observed differences between animals caused by average genetic differences.

Genetic correlation is the average genetic association between traits.

Interval between generations is the average age of sires and dams when offspring are born (which in our herd was 4.4 years).

Procedure

An experiment to study selection effects in beef cattle was started in 1960 with the Hereford herd at the Fort Robinson Beef Cattle Research Station, Crawford, Nebr. Foundation cows came from 14 different herds and were the progeny of 130 different bulls. Forty-two sires were used in the formative years.

In 1960, about 325 cows were randomly divided into three lines. Weaning weight, standardized to 200 days and adjusted for age of dam, was the selection criterion to pick replacement bulls and heifers in one line (WWL). Adjusted final weight, at 424 days for bulls and 500 days for heifers, was the selection criterion in a second line (FWL). In the third line, selection was based on an index giving equal emphasis to adjusted final weight and a muscling score (IXL). Selected bulls and heifers born in 1960 produced the first selected generation in 1963.

Each line was expanded and maintained at about 150 cows and 6 sires for any given year. Two or three bulls, selected on their respective criteria, were retained in each line each year. Bulls were used first as 2-year-olds and continued in service for 2 or 3 years. Lines were maintained at 150 cows by retaining 25 or more bred heifers per line and removing an equal number of cows. Cows were removed according to criteria in the following priority.

(1) Not pregnant when examined at weaning time,
(2) Serious unsoundness,
(3) Failure to raise a live calf, and
(4) Oldest age.

The cattle were transferred to MARC in 1971. A *control* line was established at that time by breeding 225 of the remaining foundation cows with semen stored from foundation bulls. This line serves as a base of comparison for selected and unselected cattle.

Selection Applied

Selection differentials of replacement sires were calculated by expressing records as deviations from the average of their respective year line-sex group.

For example, the two sires selected in the weaning weight line from the 1966 calf crop had selection differentials as shown in Table 1.

In a typical year, there were 64 to 75 bulls in a line-year group at weaning. Of these, 60 to 70 bulls completed postweaning performance in sound condition. Two or three of these bulls were selected on the basis of their weaning weight (WWL) or final weight (FWL). In the IXL, the deviations for final weight and muscle score were combined in such a manner that the bulls with the largest average deviation (index) were selected. Mean selection differentials of selected sires are shown in Table 2.

Selection differentials in Table 2 emphasize that primary selection for one trait may lead to significant selection differentials in other traits because of natural correlation between traits or chance. Selection differentials of all traits and their normal relationships were considered in interpreting the amount of total selection practiced and response expected in each trait.

Selection of replacement heifers in each line was similar to selection procedures for bulls. All remaining heifers were exposed to bulls during the summer breeding season. On the average, 90% of the heifers became pregnant, and selection of replacements was restricted to the 25 to 35 "best" pregnant heifers. Selection differentials of the replacement heifers are shown in Table 2.

Sires and dams contribute equally to the average genetic makeup of offspring. Comparative size of bull and heifer selection differentials illustrates the often quoted phrase that "most of the selection intensity must come from bull selection." In the case of weaning weight in WWL, 80% of the total selection was due to bulls, and for final weight in FWL, 86% of the selection was due to bulls.

Total Selection And Response

The total mid-parent selection differentials (average of sires and dams), average performance for the years 1977

Table 1.—Selection differentials of sires in weaning weight line, 1966

Trait	Avg 1966, WWL, bulls	Record	Selection differentials	Record	Selection differentials
Birth wt....lb	77	64	-13	89	12
Wean. wt ..lb	465	518	53	541	76
Yrlg. wt....lb	996	1081	85	1037	41
Muscle score	81	82	1	81	0

Table 2.—Selection differentials of selected sires and dams[1]

Selection	Birth weight		Weaning weight		Final weight		Muscle score	
	Sires	Dams	Sires	Dams	Sires	Dams	Sires	Dams
Weaning wt	7.8	1.6	75	19	110	21	1.2	0.4
Final wt	6.6	1.5	57	12	140	19	1.6	0.4
Index	7.0	2.0	54	14	116	25	3.6	0.4

[1]From Buchanan, D.S. 1979. Selection for growth and muscle score in beef cattle. Ph.D. Thesis. University of Nebraska, Lincoln. 160 p.

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to 1979, selection response, and realized heritability are shown in Table 3.

Total selection from 1963 to 1978 is not as large as might be anticipated from looking at the selection in Table 2 because many calves born in the years 1961 to 1970 had foundation parents with zero selection differentials.

Selection responses, calculated from the differences between the performance of selected and control lines, show significant increases in all traits over the control.

Realized heritability represents that fraction of parental selection differentials due to differences in average genetic merit and recovered in terms of increased (or decreased) performance of offspring. Realized heritabilities in Table 3 are the ratios of selection responses to midparent selection differentials.

Birth weight increased in all lines because of direct selection as a part of weaning or final weight and from correlated response associated with gain from birth to weaning or final ages. We estimate that the increase in birth weight could be reduced by 30% if all growth selection was directed to gain after birth instead of selecting for total weaning or final weight.

Selection response in weaning weight was highest in WWL and IXL. Although selection for weaning weight in IXL was significantly lower than in WWL, the response was about equal or higher, indicating a higher realized heritability. The slightly lower heritability for weaning weight in FWL could be due to chance or to unknown negative factors associated with the intense selection for postweaning gain.

The highest response in final weight was in IXL even though more selection was applied in FWL.

The greatest response in muscle score was in IXL, which also had the largest selection differential.

Table 3.—Total midparent selection, average performance, selection response, and realized heritability

Trait and line[1]	Midparent selection differential	Average performance 1977 to 1979	Selection response	Realized heritability
Birth weight, lb:				
Control	0	76.6	0	0
WWL	16.2	83.7	7.1	.44
FWL	14.7	82.7	6.2	.42
IXL	14.5	85.9	9.3	.64
Weaning weight, lb:				
Control	0	397.8	0	---
WWL	163	430.0	32.2	.20
FWL	116	418.2	20.5	.18
IXL	116	431.2	33.6	.29
Final weight, lb:				
Control	0	836.9	0	---
WWL	220	902.8	65.9	.30
FWL	270	910.7	73.9	.27
IXL	245	934.0	97.2	.40
Muscle score:				
Control	0	80.9	0	---
WWL	2.6	81.4	.5	.19
FWL	3.5	81.3	.4	.11
IXL	6.7	82.1	1.2	.18

[1]WWL = weaning weight line; FWL = final weight line; IXL = index line.

Correlated Response To Selection

As birth weight increased in selected lines, percentage of first-calf heifers requiring assistance at calving increased. Average birth weights and percentages of assisted births for males and females are shown in Table 4. A significantly higher percentage of heifers in the selected lines required assistance compared to the control line. Also, more heifers producing male calves required assistance than heifers producing female calves. All of the increased assistance among male calves could not be accounted for by higher birth weights. Possibly the extra difficulty is due to shape or bone structure.

Efficiency of gain is largely determined by differences in composition of gain produced, differences in weight maintained, and number of days weight is maintained. Average daily gain of bulls during the postweaning gain test, and the efficiency of gain, expressed as pounds of gain per megacalorie of metabolizable energy consumed for the years 1972 through 1978, are shown in Table 4. The evaluation was made over a weight constant interval that averaged 500 to 900 lb. Selected line bulls gained more rapidly and had better efficiency of gain than the control line bulls. Average feed consumption per day did not differ significantly among control and selection line bulls.

No measurements of composition of gain were obtained. However, data from steers produced in 1963 to 1970 indicated that genetic increase in rate of gain is associated with slight increases in lean and decreases in fat percentages at equal weights. The more rapid gains of the selection lines meant that they took 10 to 15 days less to gain the 400 lb and, thus, had fewer days of weight maintenance.

The evidence from this experiment indicates selection is effective in making slow (½ to ¾ percent per year) but steady changes in growth traits. Growth measured at birth and during the postweaning period was more highly heritable than growth from birth to weaning. Growth in one period was positively genetically correlated with growth in other periods. The genetic increase in growth rate was associated with increased calving difficulty and with increased efficiency of gain.

Table 4.—Calving assistance in 2-year-olds, postweaning daily gain, and efficiency of gain through a weight constant interval (400-900 lb)

	Calving assistance				Postweaning gain test		
	Males		Females				
Line[1]	Birth wt (lb)	Percent assisted	Birth wt (lb)	Percent assisted	Daily gain (lb)	Gain per Mcal ME	Days fed
Control	71	50	66	19	2.24	0.113	176
WWL	78	58	73	38	2.40	0.119	165
FWL	78	64	72	43	2.43	0.122	163
IXL	82	77	75	39	2.47	0.121	161

[1]WWL = weaning weight line; FWL = final weight line; IXL = index line.